UT/LS H_2O validation issues

Important issues that remain unresolved:

- Establishing the frequency and also temperature dependence of supersaturation.

- Establishing instrumental accuracy at low water vapor values and low temperatures.

Karen Rosenlof and David Fahey
NOAA ESRL CSD
Aura Validation Working Group Meeting
Pasadena Convention Center
October 1, 2007

In June 2007, a workshop was held in Karlsruhe, Germany "International Workshop on Upper Tropospheric Humidity" (partially SPARC sponsored)

The questions discussed in the workshop boil down to:

(1) At what supersaturation do we expect ice to nucleate?

(2) Thereafter, how rapidly do we expect ice to grow and supersaturation to equilibrate ($S \rightarrow 1$)?

where:

$$S = \frac{p_{H_2O}}{p_{vap}(T)} = \frac{partial\ pressure\ of\ water}{vapor\ pressure\ of\ ice}$$

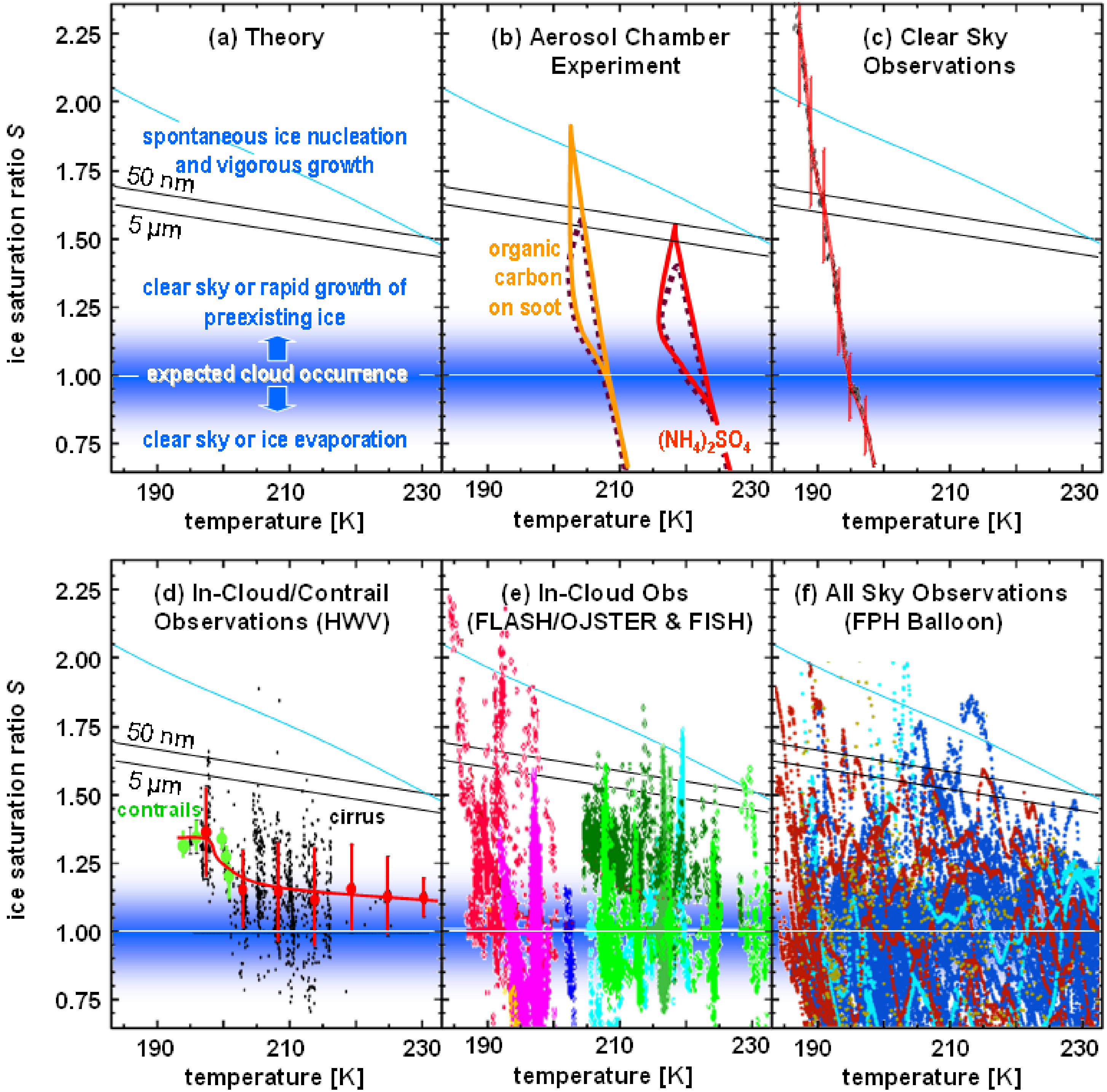


Figure from Thomas Peter:

Black curves are from Koop et al, 2000, blue curve is water saturation

Conclusions – Summary of Potential Explanations: (T. Peter)

→ **How good are the data?** — ***Not good, but good enough to accept persistent S > 1.2 inside and S > 1.6 outside clouds …***

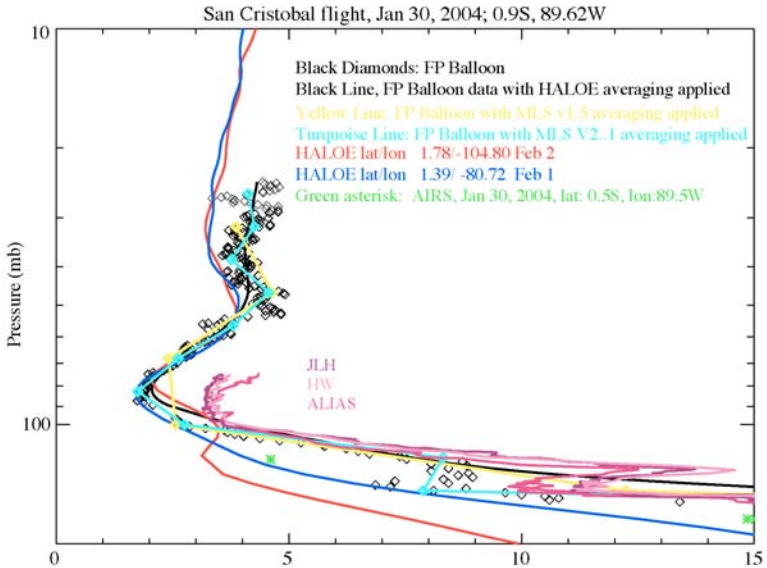
→ **Potential out-of-cloud effects:**

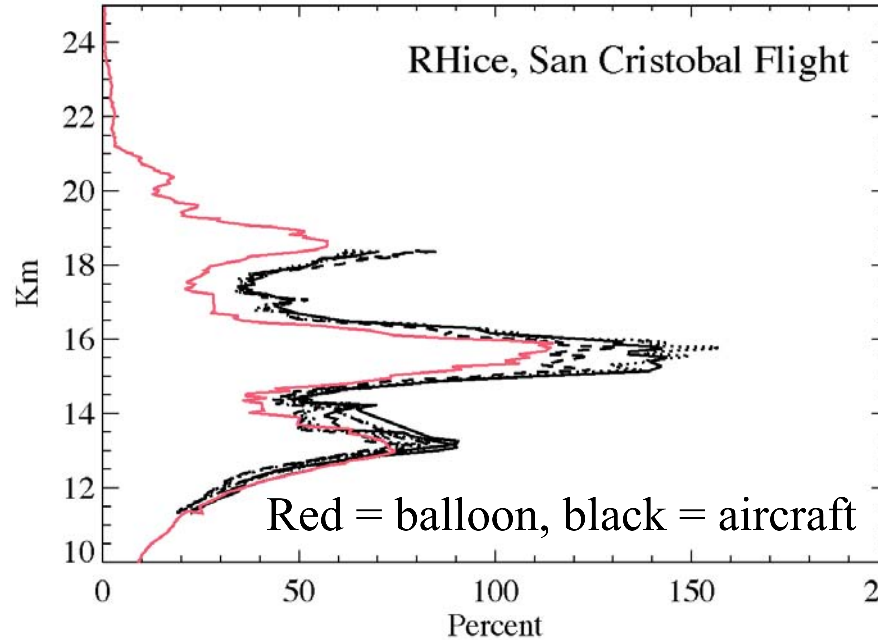
- ***Lack of preexisting aerosol?*** — ***No***
- ***Low mass accommodation of H_2O on aerosol?*** — ***Hot candidate***
- ***Underestimated vapor pressure of supercooled water?*** — ***10 %***
- ***Surface nucleation?*** — ***Speculative***
- ***Glass formation?*** — ***New***
- ***Viscous Ih-Ic mixtures?*** — ***New***

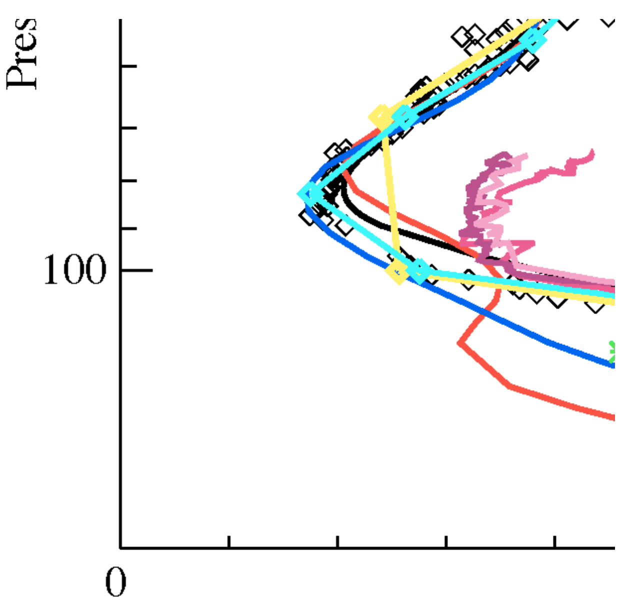
→ **Potential in-cloud effects:**

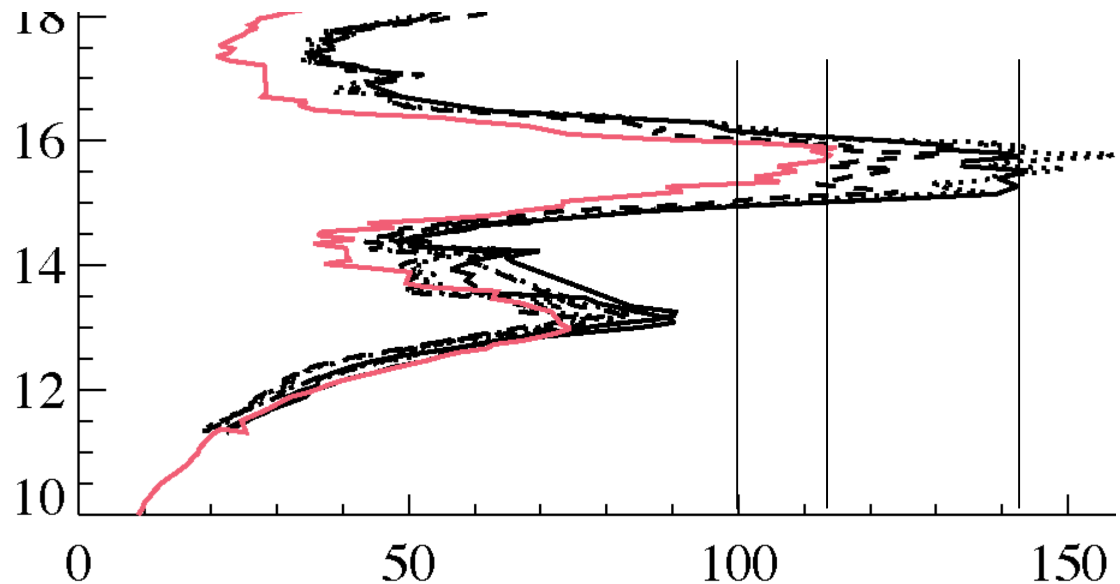
- ***Control by ice nuclei?*** — ***Not persistent***
- ***Mesoscale temperature fluctuations?*** — ***No***
- ***Mesoscale subresolution patchiness?*** — ***Hot candidate***
- ***Microscale subresolution patchiness?*** — ***New***
- ***HNO_3 deposition on ice, forming NAT?*** — ***Lab evidence missing***
- ***Low mass accommodation of H_2O on ice?*** — ***Very hot candidate***
- ***Cubic ice?*** — ***Hot candidate***
- ***Overpopulated tail of high velocity molecules?*** — ***Speculative***

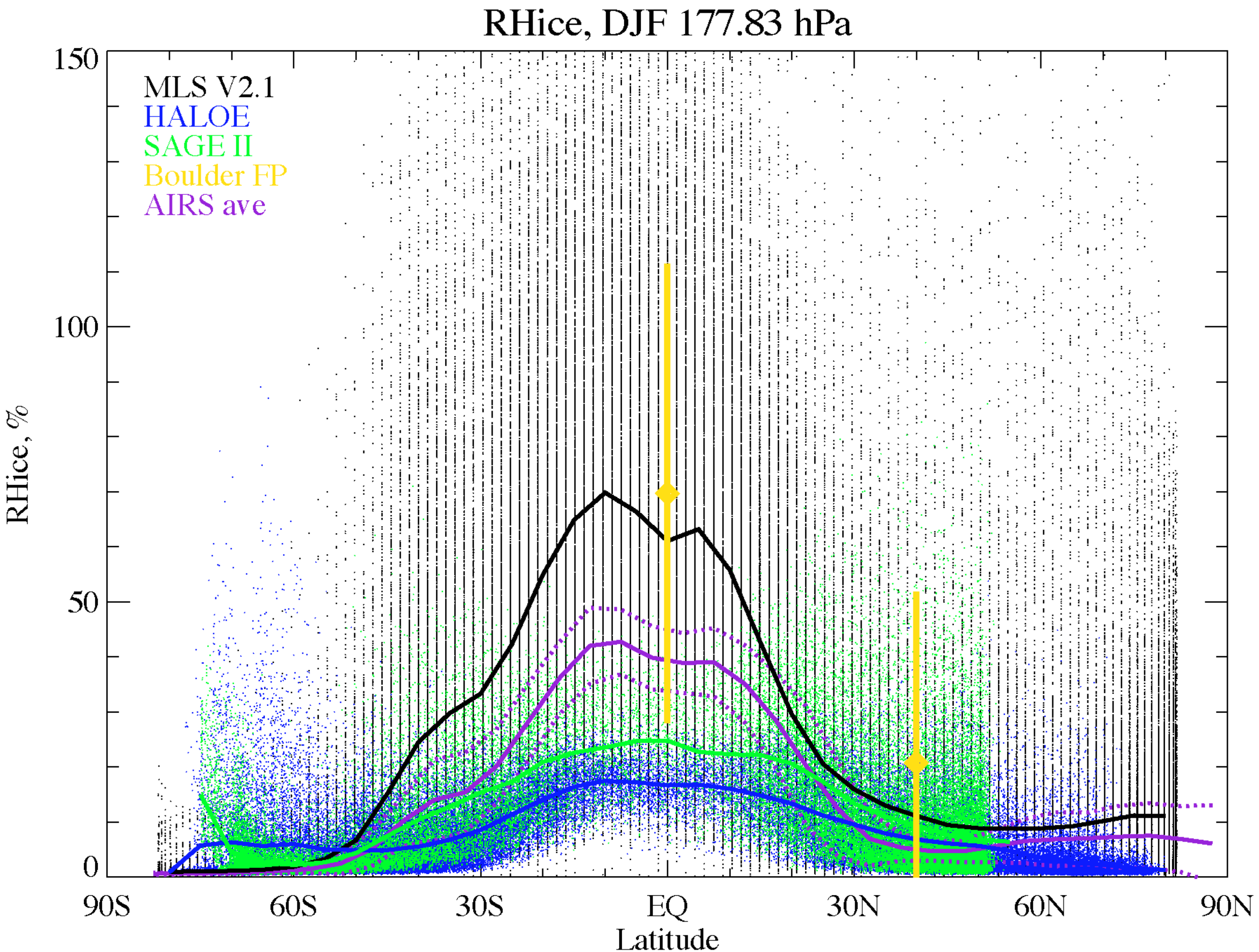
HOW UNCERTAIN ARE THE DATA? Important question for satellite validation.

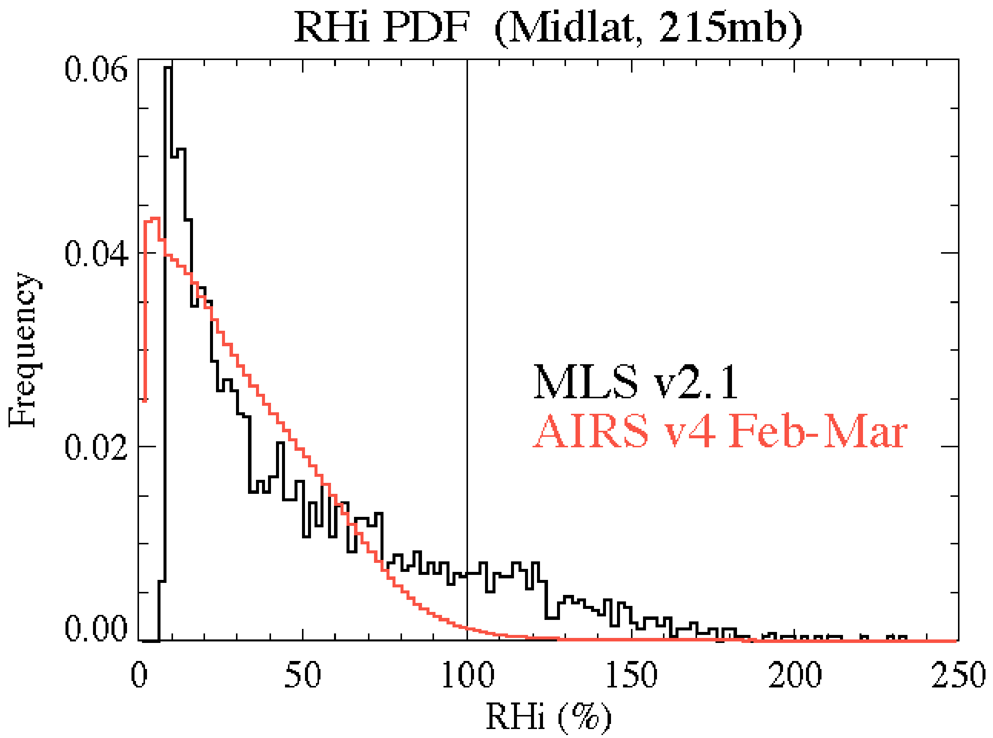




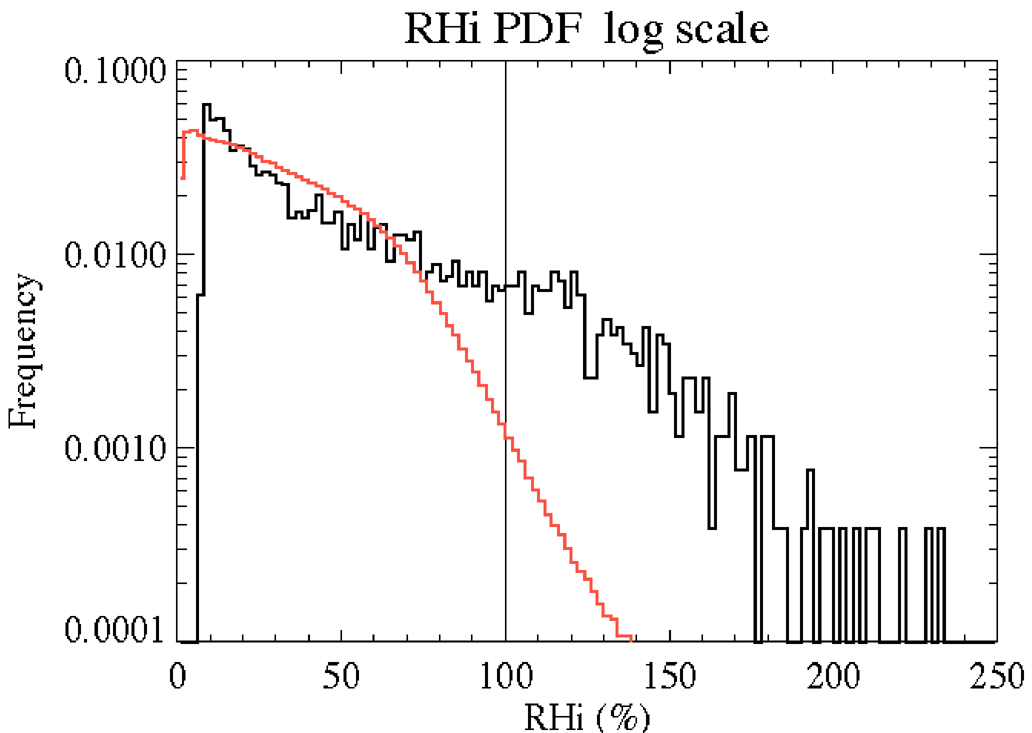





RHice, DJF 177.83 hPa
MLS V2.1
HALOE
SAGE II
Boulder FP
AIRS ave
150
100
50
0
RHice, %
90S
60S
30S
EQ
30N
60N
90N
Latitude



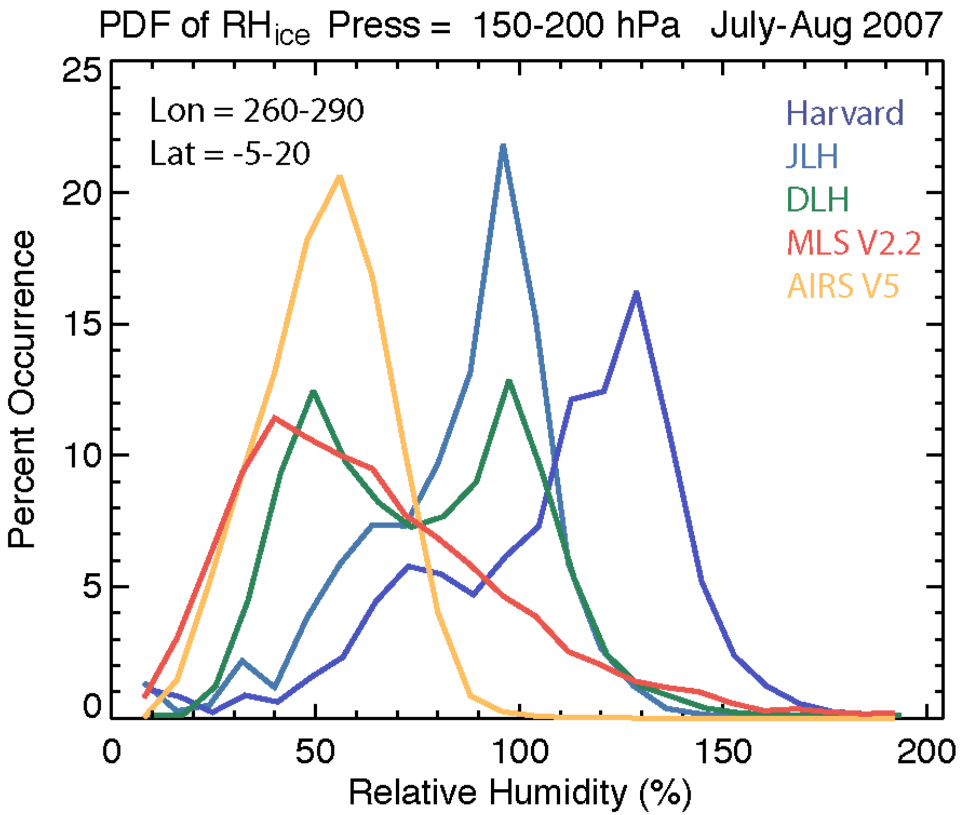
How do estimates of frequency of high RH_{ice} differ?

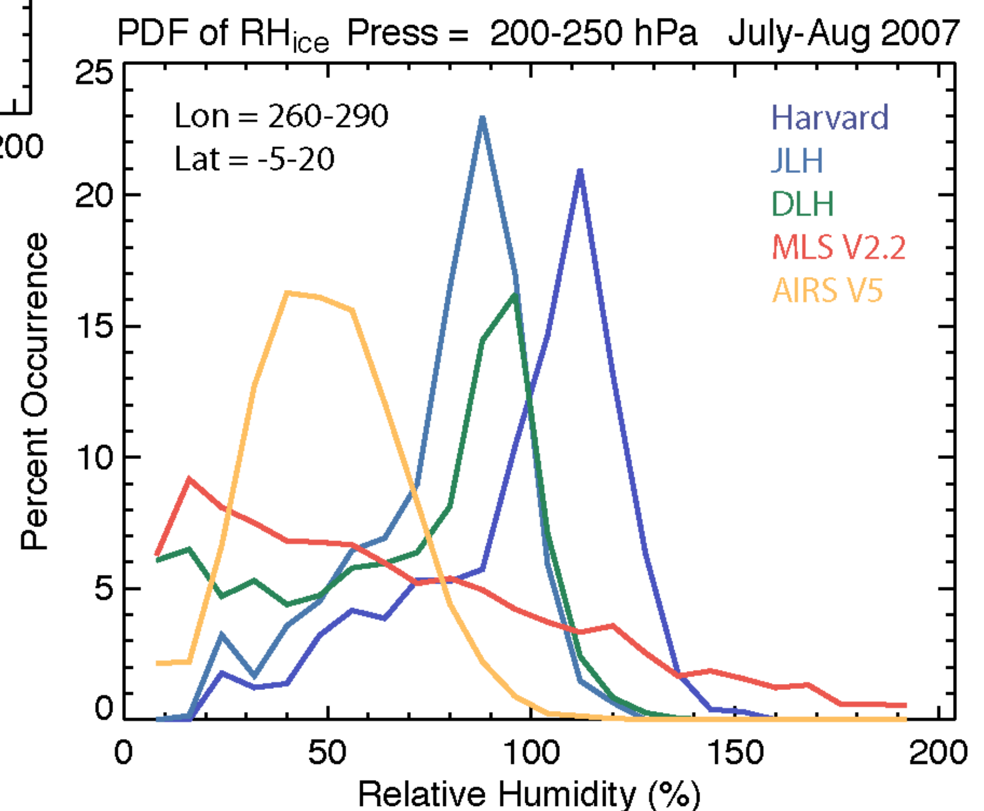


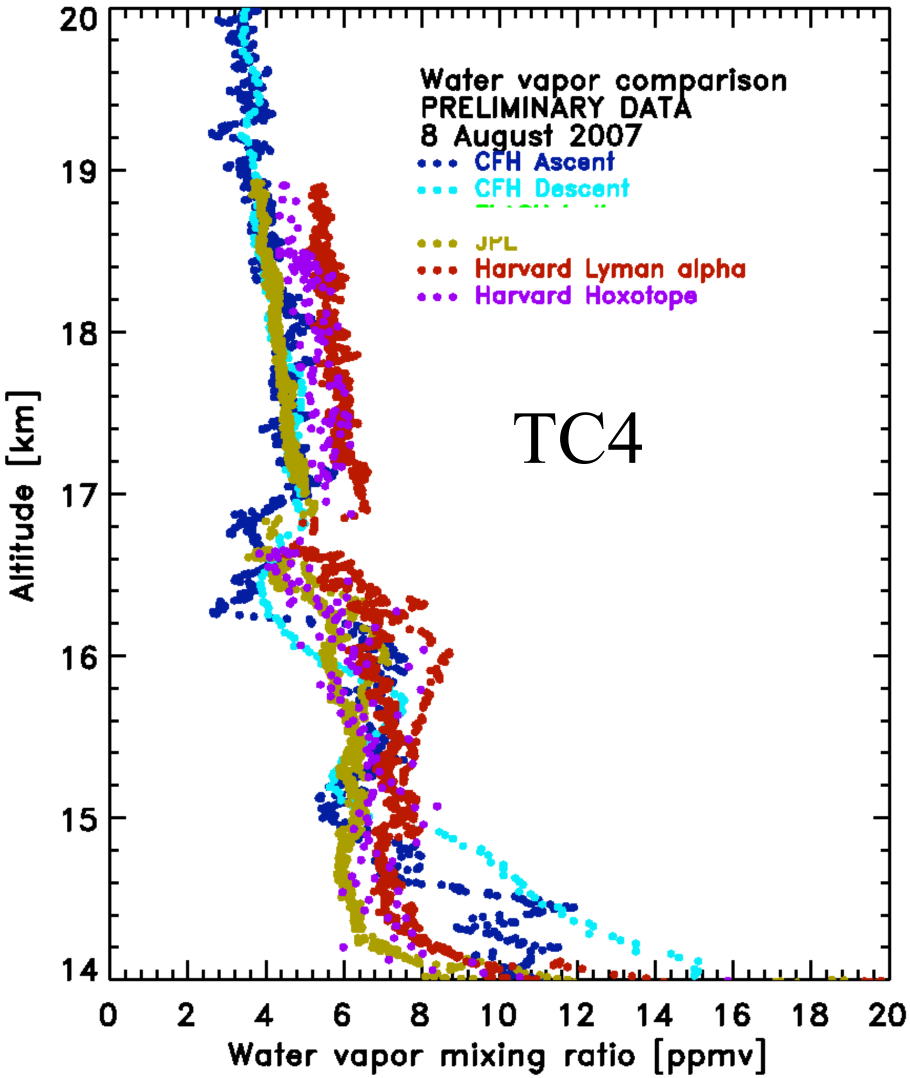
Frequency of very high RH_{ice} greater for MLS than for AIRS.

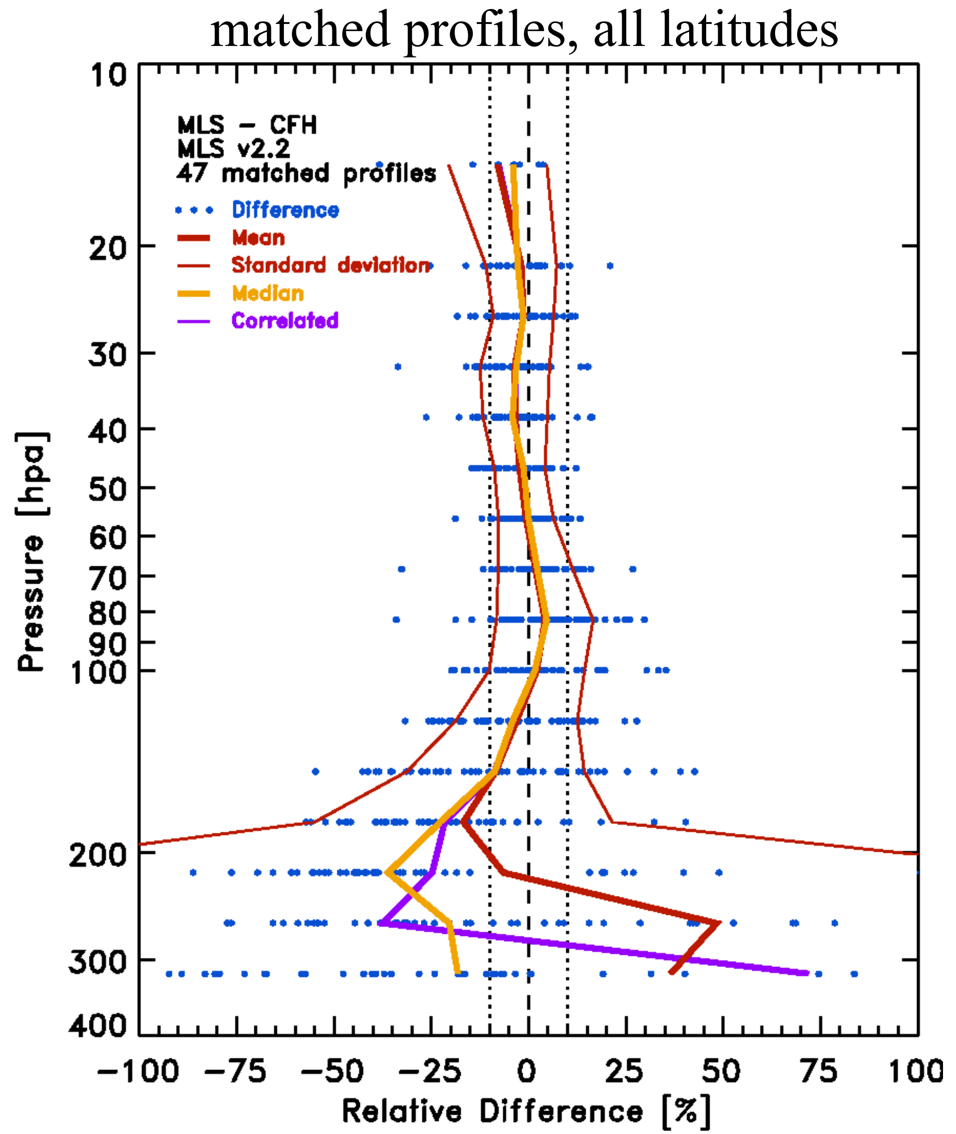
From Andrew Gettelman

TC4 analysis









From H. Vömel (will be explained in greater detail in his talk in the plenary session on Wednesday morning)

% differences between instruments largest at low mixing ratios.

Significant differences exist between water vapor instruments in the UTLS. *Note, these differences are large enough that interpretations as to processes occurring in the atmosphere can change by simply using data from different instruments.*

Assessing the reasons for these differences and establishing what the accuracies of the measurements actually are should be a priority before using such measurements for validation or for reassessing cloud physical parameterizations.

To address the accuracy question at low values, there will be an experiment in Germany called AquaVIT {Aqua Validation and Instrument Tests}

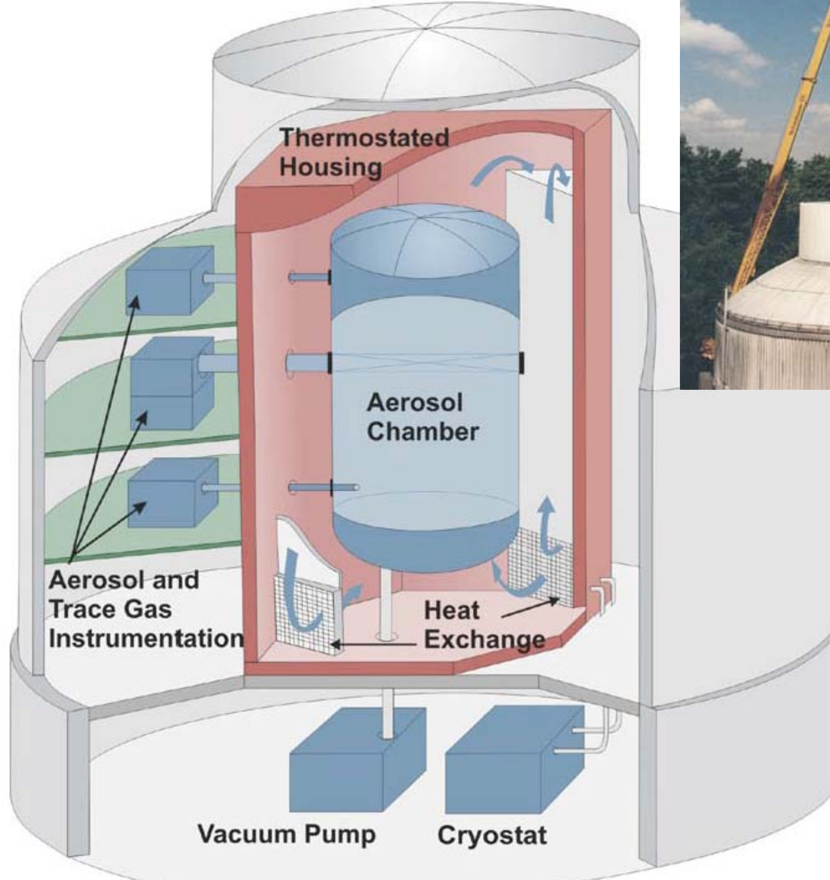
This is an intercomparison campaign of water vapour measurement techniques to be held in the AIDA Chamber in in Karlsuhe October 8th - November 2nd, 2007, Karlsuhe, Germany. (*http://imk-aida.fzk.de/campaigns/RH01/Water-Intercomparison-www.htm*)

Formal intercomparison campaign at the AIDA aerosol & cloud chamber, during which most of the relevant measurement methods and instruments will be compared for a range of well-defined atmospheric conditions

What is the AIDA chamber?

Aerosol Interaction and Dynamics in the Atmosphere

Forschungszentrum Karlsruhe, Germany



- The AIDA aerosol and cloud simulation chamber allows controlled variation of the following parameters:
- - Temperature range: 183 to 313 K
- - Water concentrations: 0.3 ppm (1atm) to nearly saturation with respect to ice at static (T,p)-conditions
- - Ice saturation ratios of more than 2 during dynamic expansion experiments (for time periods from a few minutes up to about 30 min)
- - Total pressure: 0.01 to 1000 hPa (experiments are typically conducted above 100 hPa)
- - With/without aerosol particles or water/ice clouds (including supersaturation)

AquaVIT

- ➔ Bring together the atmospheric water measurement community including water vapour and total water measuring instruments.

- ➔ Determine the instrument performances for static conditions (pressure, temperature, & water constant) and dynamic conditions (changing pressure, temperature, water, cloud density) for low water concentrations (1 - 20 ppm). Reasons for possible discrepancies will be investigated by variation of crucial parameters.

- ➔ The participating instruments will be intercalibrated among each other at the AIDA chamber and optionally in comparison with an external H_2O reference source by PTB ("German NIST"). Scientific goals beyond instrument intercomparison may be addressed, however, the intercomparison takes priority.

Detailed timeframe:

1-5 Oct 2007: Preparation of AIDA chamber

8-12 Oct 2007: Installation of the instruments and test experiments

15-26 Oct 2007: Measurements

29 Oct – 2 Nov: Backup Week

	Name	Institute	Instrument
✖	Linnea Avallone Sean Davis	University of Colorado	CLH (TDL)
	Árpád Mohhácsi Attila Varga	University of Szeged, Hilase Ltd.	Photo-acoustic water sensor
	Theo Brauers Rolf Häseler	Research Centre Jülich	Vaisala Sensor DM 500
	Ulrich Bundke	University of Frankfurt	PADDY dew point mirror
☑	Teresa Campos Frank Flocke Dennis Krämer	NCAR Boulder	NCAR OPLH
	George Durry Nadir Amarouche Jacques Deleglise Fabien Frerot	University of Reims	PicoSDLA, (balloonborne)
	Volker Ebert Christian Lauer Stefan Hunsmann	University of Heidelberg	AIDA TDL
	Harald Saathoff	Forschungszentrum Karlsruhe	AIDA TDL & MBW-373LX
	Debbie O'Sullivan	UK met office	met office fluorescence hygrometer
✖	Robert L. Herman Robert F. Troy	JPL	JPL-Laser-Hygrometer
	Cornelius Schiller Martina Krämer Armin Afchine Reimar Bauer Jessica Meyer Nicole D. Spelten Andres Thiel Miriam Kübbeler	Research Centre Jülich	FISH & Ojster TDL & MBW-DP30
✖	Sergey Khaykin Leoind Korshunov	Central Aerological Observatory	Two FLASH-B (Lyman-a)
✖	Holger Vömel	University of Colorado	CFH, frost point hygrometer
✖	Elliot Weinstock Jessica Smith	Harvard University	Harvard water vapor
	Frank Wienhold Ulrich Krieger Martin Brabec	ETH Zürich	Snow-White
	Andreas Zahn Julia Keller	Forschungszentrum Karlsruhe	Buck CR-2 & photo-acoustic system
☑	Mark Zondlo	Southwest Science, Inc.	HIAPER VCSEL TDL-System

Referees:

David Fahey & Ru-Shan Gao
NOAA ESRL CSD

Ottmar Möhler
Forschungszentrum Karlsruhe

✖ TC4

☑ HIAPER